CORROSION ISSUES

- Phil Sadler, Senior Utilities Safety Engineer
- Noel Travis, Utilities Safety Engineer

CORROSION ISSUES

SISSONVILLE, W. Va.December 11, 2012, 20-inch natural gas transmission pipeline running west to east, perpendicular to Interstate 77, ruptured about 112 feet west of Interstate 77

CORROSION ISSUES

The pipeline operating pressure at the time of the rupture was about 929 psig. Fire damage extended nearly 1,100 ft. along the pipeline and about 820 ft. wide.

CORROSION ISSUES

About 20 feet of pipe was ejected from the pipeline and landed more than 40 feet from its original location.

The outside surface of the pipe was heavily corroded. The wall thickness had degraded so significantly that it measured about 70% thinner than the original wall thickness.

The Charleston Gazette
July 30, 2013

Sissonville residents sue over gas pipeline explosion

CHARLESTON, W.Va. – "Several Sissonville residents sued Columbia Gas Transmission over December's massive gas line explosion and fire."

"In seven separate lawsuits, the residents allege the companies and others didn't "exercise due care" in maintaining the transmission pipeline that ruptured."

"The lawsuits, filed for the residents by Warner Law Offices of Charleston, allege the companies failed to adequately train employees in safety inspection in regard to maintaining the gas transmission lines. They also claim inadequate training in emergency response. "

"Also named as defendants in the case are company employees who were involved in managing how the company inspected and repaired pipelines, or in the direct response to the Sissonville explosion."

"Including : the director of gas control ,corrosion technicians or specialists and the manager of corrosion."

NTSB released documents from Sissonville pipeline explosion

All of the following have been identified by the WV PSC inspector as potential probable violations of §192.13(c), wherein the operator failed to maintain, modify as appropriate and follow its manual of written procedures.

§192.477 failed to monitor coupons on 2 drips for internal corrosion at the required interval - 15 days beyond the 7.5 month interval.

§192.705 failed to patrol road crossings with shorted casings at 4 road crossings -3 days over 7.5 month interval.

§192.706 failed to conduct leak surveys in a Class 3 area where unodorized gas is being transported at required interval - 24 days over 7.5 month interval.

§192.463(c) failed to determine voltage levels that would not damage protective Coating.

The list continues……

There were over 50 probable violations…..

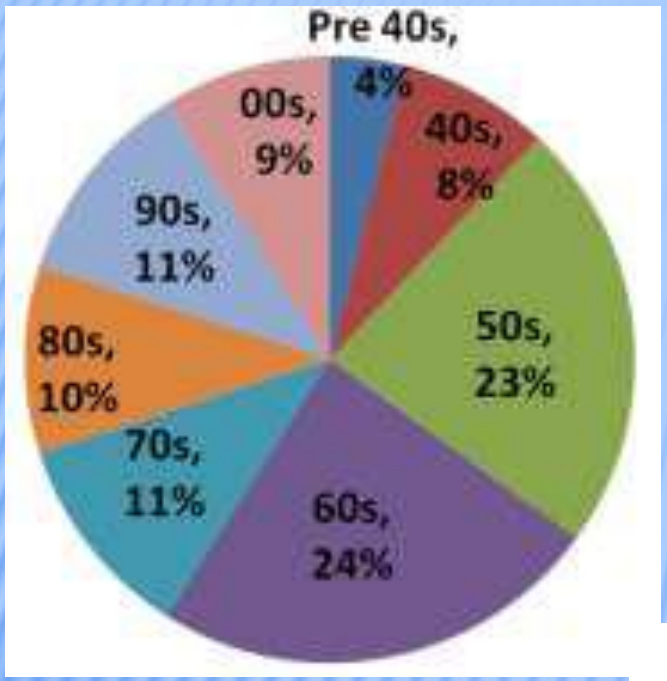
External Corrosion

Atmospheric Corrosion

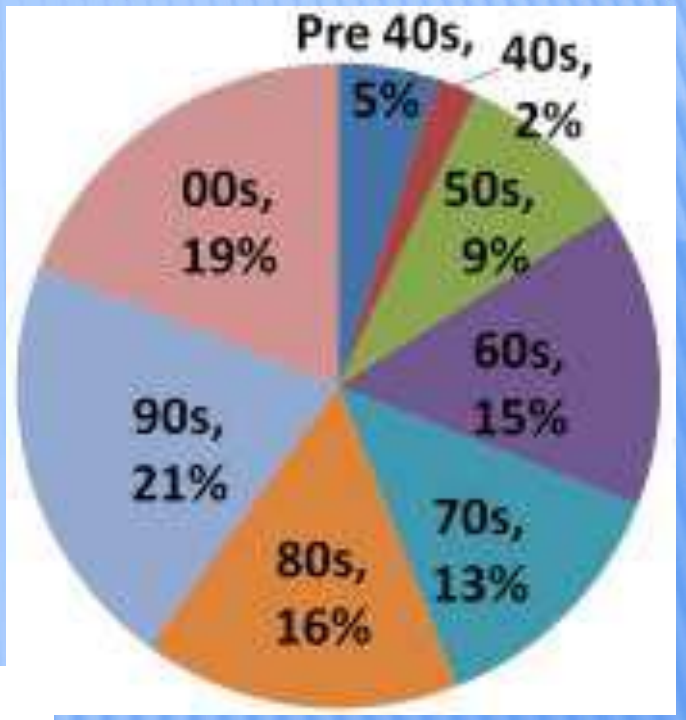
Internal Corrosion

Nationwide Age of Pipelines

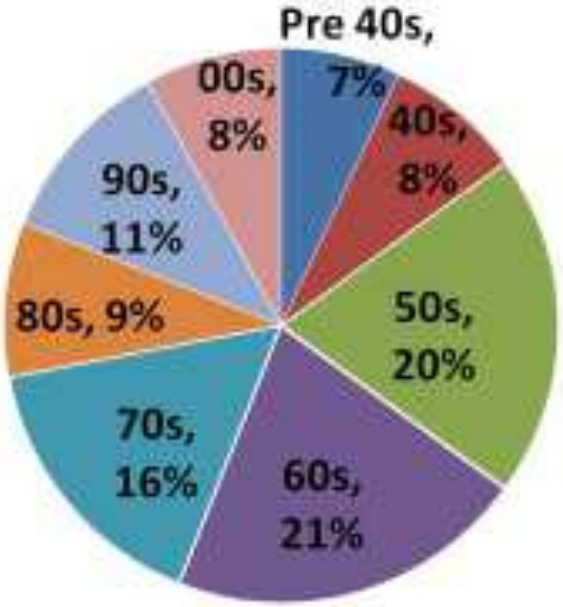
Gas Transmission



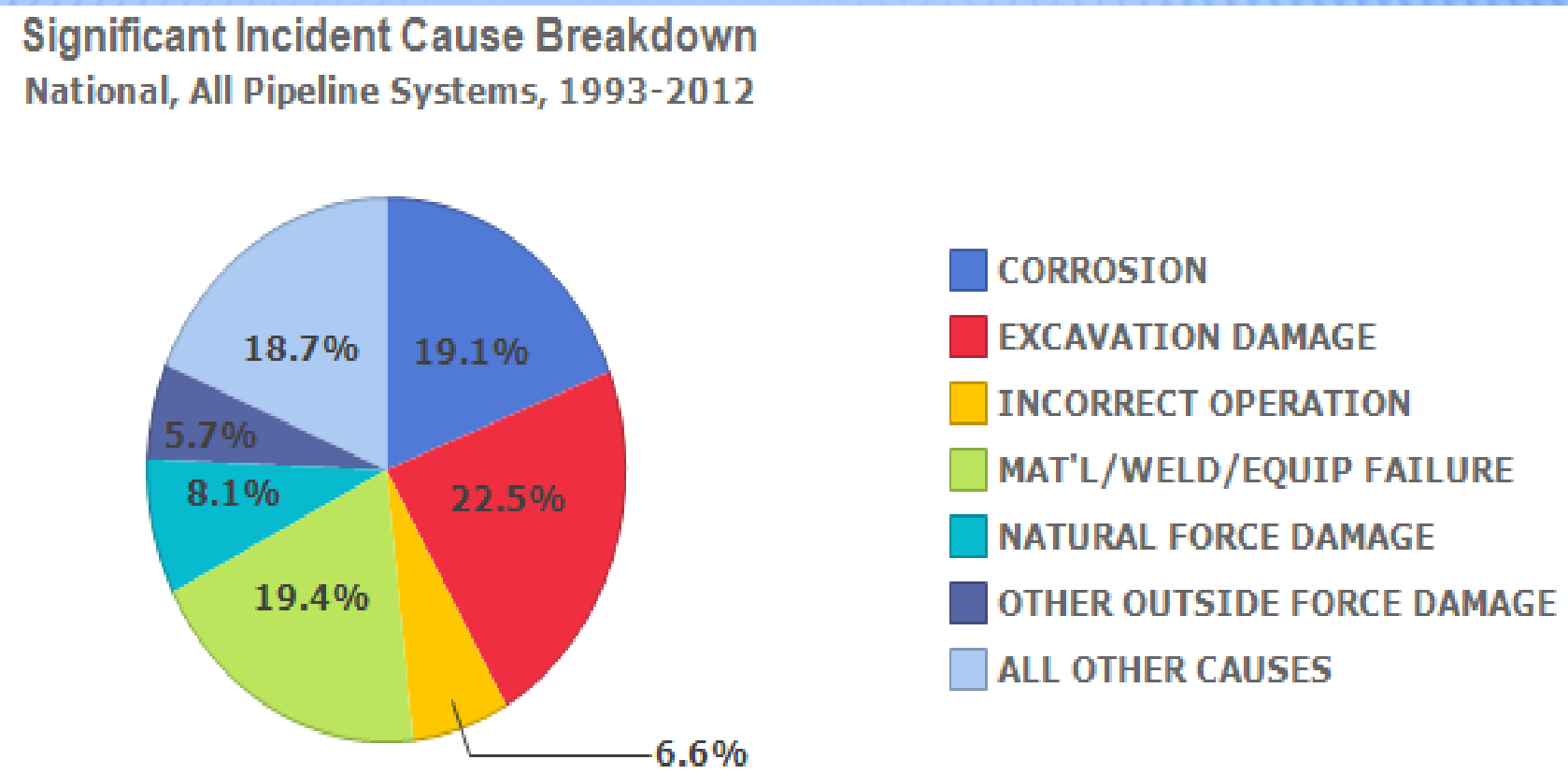
Gas Distribution



Hazardous Liquid



CORROSION ISSUES



Source: PHMSA Significant Incidents Files, Aug 30, 2013

CORROSION ISSUES

National All Pipeline Systems: Significant Incident Details: 1993-2012

Reported Cause of Incident CORROSION	Number of incidents	Percentage of total incidents	Fatalities	Injuries	Property Damage (Millions)
EXTERNAL CORROSION	545	9.7%	11	69	$400,000,000
INTERNAL CORROSION	510	9.0%	13	6	$284,000,000
UNSPECIFIED CORROSION	17	0.3%	1	11	$6,000,000
Sub Total	**1,072**	**19.1%**	**25**	**86**	**$690,000,000**

VIRGINIA CORROSION ISSUES

Virginia (2008-2012) total reported leaks 55,564, 8894 were corrosion leaks (16%)

Commission staff took action to address operators CP programs

CASE NO. URS-2009-00338

Code PV	Remedial Action
§ 192.453 – Failure of Company to have all of the corrosion control procedures required including those for the design, installation, operation, and maintenance of cathodic protection systems, carried out by, or under the direction of, a person qualified in pipeline corrosion control methods;	Shall hire an additional full time Employee (Corrosion Control Supervisor) on its staff who is qualified pursuant to § 192.453 to carry out the corrosion control procedures required by Subpart I of 49 C.F.R. Part 192 and 49 C.F.R. § 192.605 (b)(2).

VIRGINIA CORROSION ISSUES

CASE NO. URS-2009-00338

Code PV

49 C.F.R. § 192.465 (a) - Failing on two occasions of Company to demonstrate that at least 10 percent of the protected pipeline short sections, distributed over the entire system have been surveyed (tested for adequacy of the cathodic protection) each calendar year, with a different 10 percent surveyed each subsequent year, culminating in the entire system being tested in the previous 10-year period;

49 C.F.R. § 192.465 (d) - Failing on multiple occasions of Company to take prompt remedial action to correct any deficiencies indicated by the cathodic protection monitoring;

49 C.F.R. § 192.469 - Failing on multiple occasions of Company to provide each pipeline under cathodic protection with sufficient test stations or other contact points for electrical measurement to determine the adequacy of cathodic protection.

VIRGINIA CORROSION ISSUES

Remedial Actions

Shall employ an outside consultant to perform an independent evaluation ("Evaluation") of the policies, procedures, operation, maintenance, and facilities of the Company's cathodic protection corrosion control program.
"complete all of the remediation and other corrective actions determined by the Consultant"

Shall begin revising its operations and maintenance manuals procedures relative to corrosion control to provide detailed section guide procedures for the Company's employees to use for compliance activities.

Shall enhance the Company's quality control for construction related activities by, among other things, increasing the number of Company's construction inspectors by six (6) full time employees, the number of utility expediters by two (2) full time employees, the number of Contract Inspectors by one (1) full time employee, and the number of Construction Supervisors by one (1) full time employee.

Shall complete a minimum of Fifteen Million dollars ($15,000,000) of pipeline replacement projects throughout the Company's operating area.

WHAT DOES THE FEDERAL CODE REQUIRE OPERATORS TO DO?

Subpart I—Requirements for Corrosion Control

§192.451 Scope.
§192.452 How does this subpart apply to converted pipelines and regulated onshore gathering lines?
§192.453 General.
§192.455 External corrosion control: Buried or submerged pipelines installed after July 31, 1971.
§192.457 External corrosion control: Buried or submerged pipelines installed before August 1, 1971.
§192.459 External corrosion control: Examination of buried pipeline when exposed.
§192.461 External corrosion control: Protective coating.
§192.463 External corrosion control: Cathodic protection.
§192.465 External corrosion control: Monitoring.
§192.467 External corrosion control: Electrical isolation.
§192.469 External corrosion control: Test stations.
§192.471 External corrosion control: Test leads.
§192.473 External corrosion control: Interference currents.
§192.475 Internal corrosion control: General.
§192.476 Internal corrosion control: Design and construction of transmission line.
§192.477 Internal corrosion control: Monitoring.
§192.479 Atmospheric corrosion control: General.
§192.481 Atmospheric corrosion control: Monitoring.
§192.483 Remedial measures: General.
§192.485 Remedial measures: Transmission lines.
§192.487 Remedial measures: Distribution lines other than cast iron or ductile iron lines.
§192.489 Remedial measures: Cast iron and ductile iron pipelines.
§192.490 Direct assessment.
§192.491 Corrosion control records.

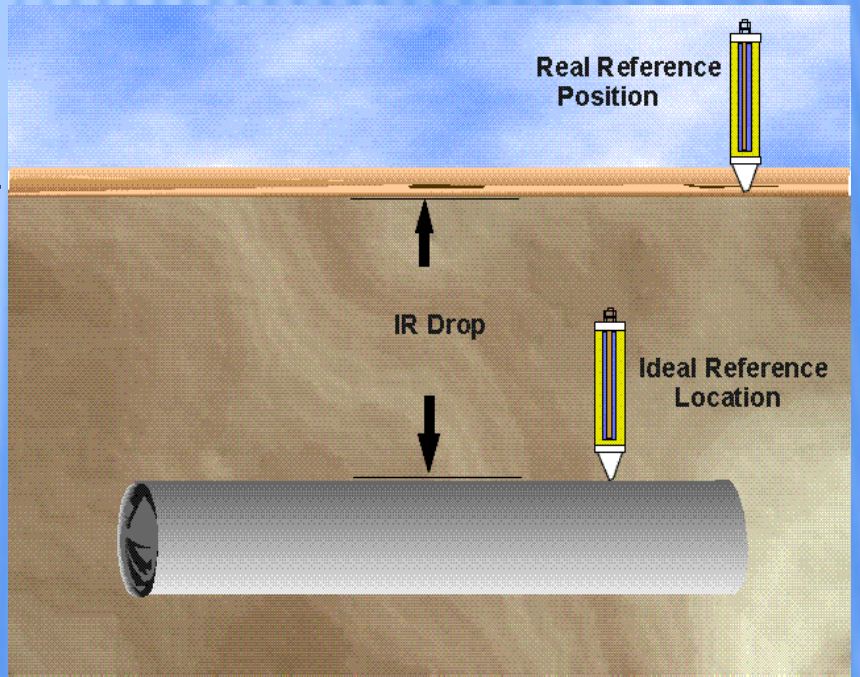
HOW DOES A CP INSPECTION WORK?

- We start by examining leak records and other historical corrosion data for an operator.
- This data provides us with information that may indicate a potential CP problem.
- Staff informs the operator of our concerns and requests additional information including on site inspections of (Circuit Packs, Protected Zones, Periodics, Corrosion Protected Areas, etc.)

HOW IS THE INSPECTION CONDUCTED?

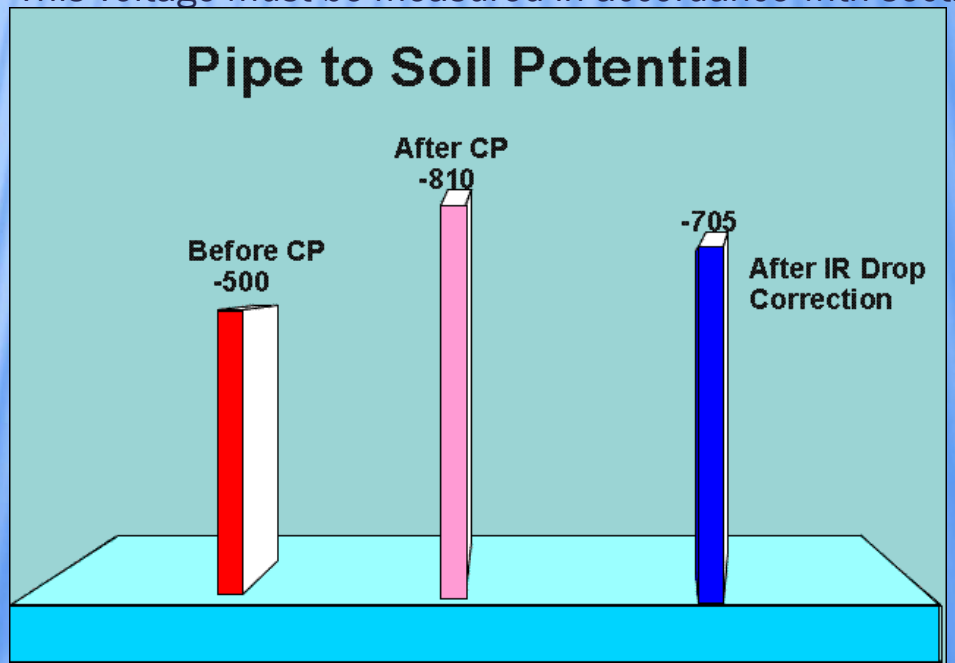
- We begin the inspection by reviewing the operators CP records, annual test station readings, OQ records and training, qualifications of the “453” person etc.

- A critical issue that is discussed is the method the operator uses to determine IR drop. Whatever method the operator uses is what we expect to see demonstrated in the field portion of the inspection.



APPENDIX D CRITERIA FOR CP

- (1) **A negative (cathodic) voltage of at least 0.85 volt**, with reference to a saturated copper-copper sulfate half cell. Determination of this voltage must be made with the protective current applied, and in accordance with sections II and IV of this appendix.
- (2) **A negative (cathodic) voltage shift of at least 300 millivolts**. Determination of this voltage shift must be made with the protective current applied, and in accordance with sections II and IV of this appendix. This criterion of voltage shift applies to structures not in contact with metals of different anodic potentials.
- (3) **A minimum negative (cathodic) polarization voltage shift of 100 millivolts**. This polarization voltage shift must be determined in accordance with sections III and IV of this appendix.
- (4) A voltage at least as negative (cathodic) as that originally established at the beginning of the Tafel segment of the **E-log-I curve.** This voltage must be measured in accordance with section IV of this appendix.



Using company provided CP maps, we go to CP circuits that may have had prior corrosion leaks or historical low CP readings. We inspect galvanic and rectified systems.

Example

Circuit Pack #47

Service Meter at 4020 Cedar Grove Street (Riser) -0.478v

Service Meter at 4022 Cedar Grove Street (Riser) -0.463v

Service Meter at 4036 Cedar Grove Street (Riser) -1.06v

Service Meter at 4044 Cedar Grove Street (Riser) -0.536v

Service Meter at 4056 Cedar Grove Street (Riser) -1.190v

Service Meter at 4045 Cedar Grove Street (Riser) -1.15v

Closest Annual Test Point in proximity to above: 4036 Cedar Grove -1.15v

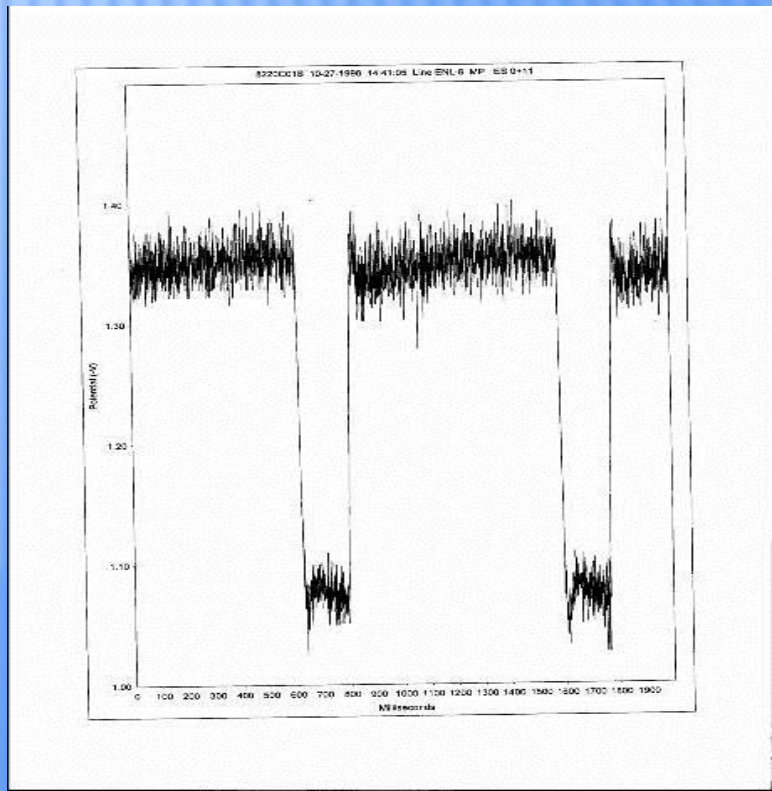
Next Closest Annual Test Point in proximity to above: Lays on next street over between 4037 & 4041 Sun Valley Crescent Street -1.15v

Annual Test Point opposite side of street from above test point: -1.14v

This Circuit Pack is a probable violation of 49CFR §§192.469 to wit: “Failure of the Company to ensure that each pipeline under cathodic protection required by this subpart to have sufficient test stations or other contact points for electrical measurement to determine the adequacy of cathodic protection.”

“453” PERSON

- The “453” Person is the “Quarterback” of the Corrosion Dept.
- The corrosion control procedures required by §192.605(b)(2), including those for the design, installation, operation, and maintenance of cathodic protection systems, must be carried out by, or under the direction of a person qualified in pipeline corrosion control methods.
- “453” person, needs to be the person to gather all the information and make informed decisions and recommendations for the effective management of the CP program.



We are finding that companies are doing the minimum.

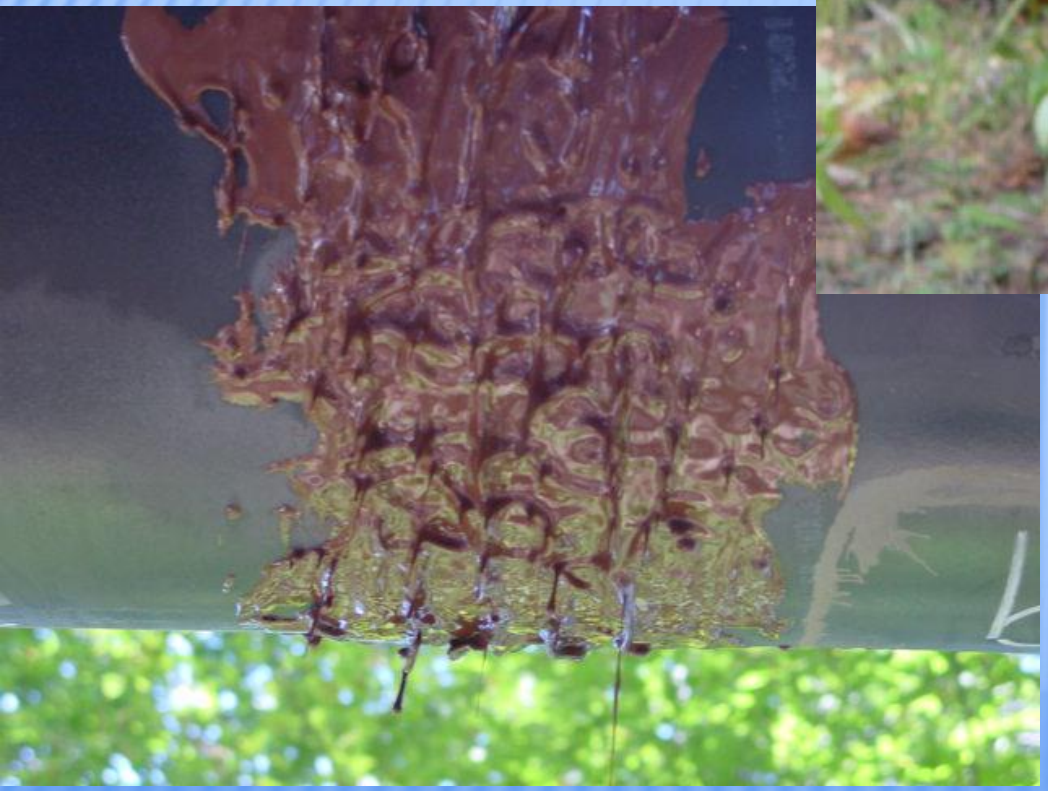
Installed in 1994, No atmospheric corrosion inspections conducted on this exposure.

AC interference on a gas main

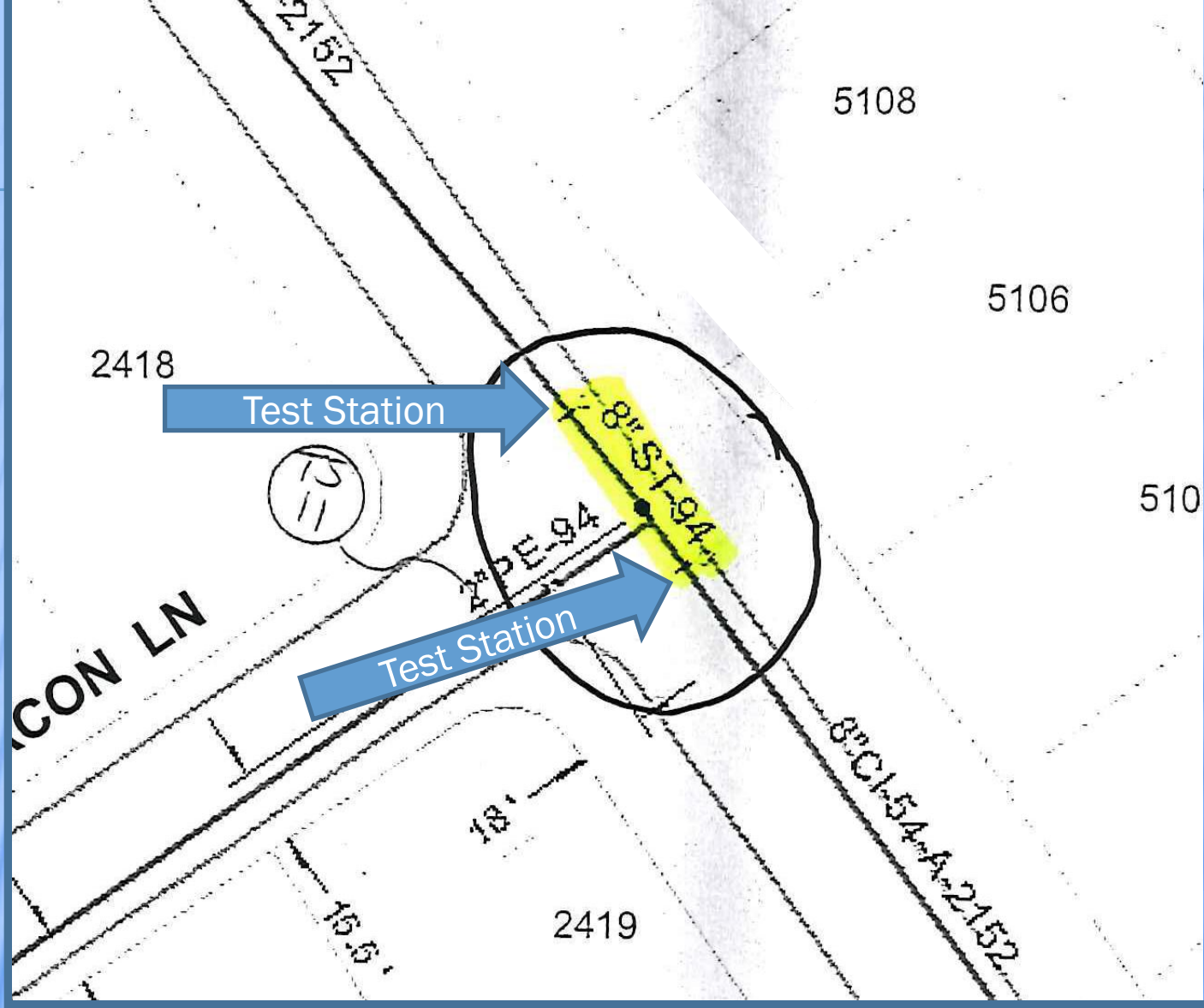
Test stations paved over

Missing / broken test station leads

Bad coating issues

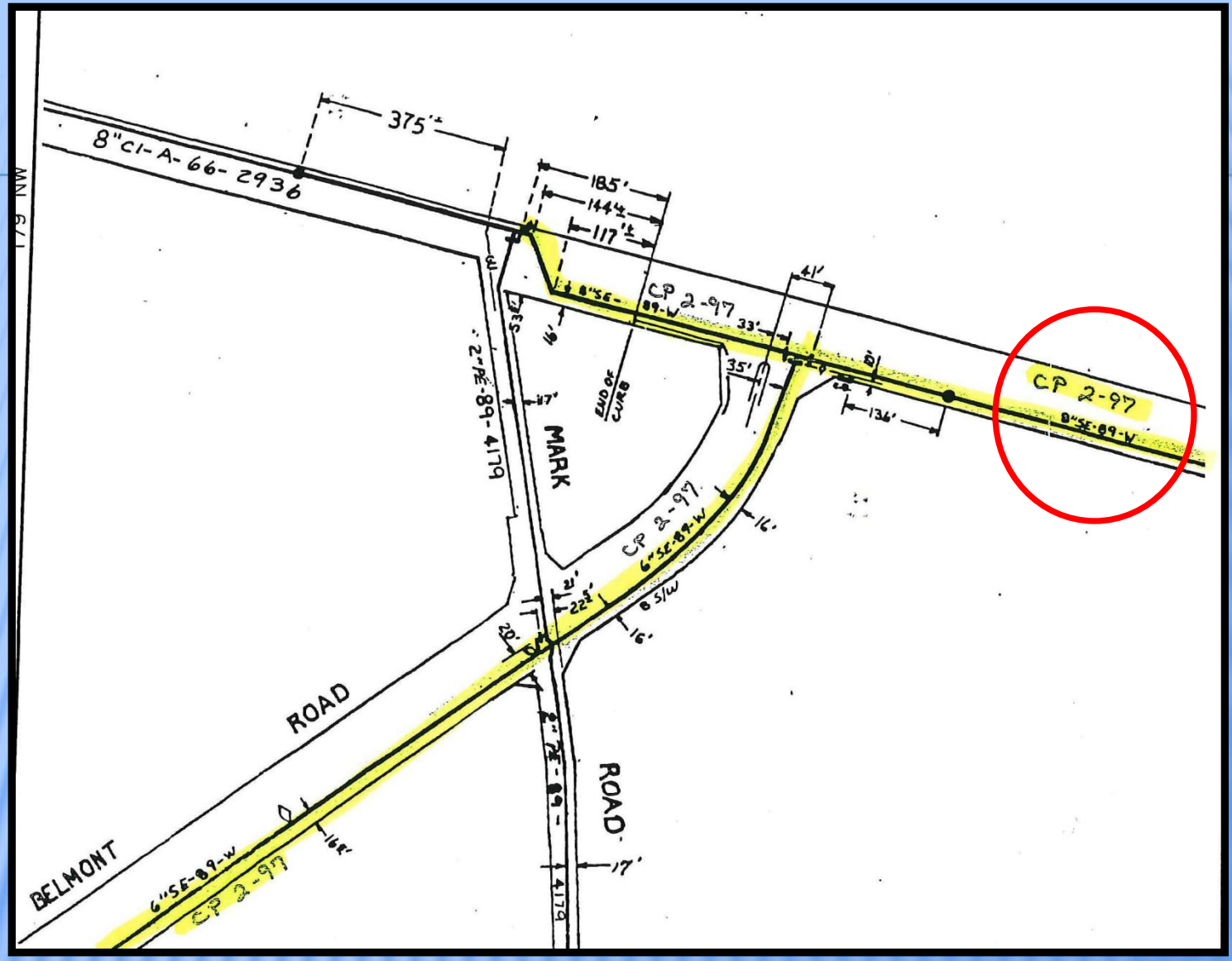


Bad coating issues

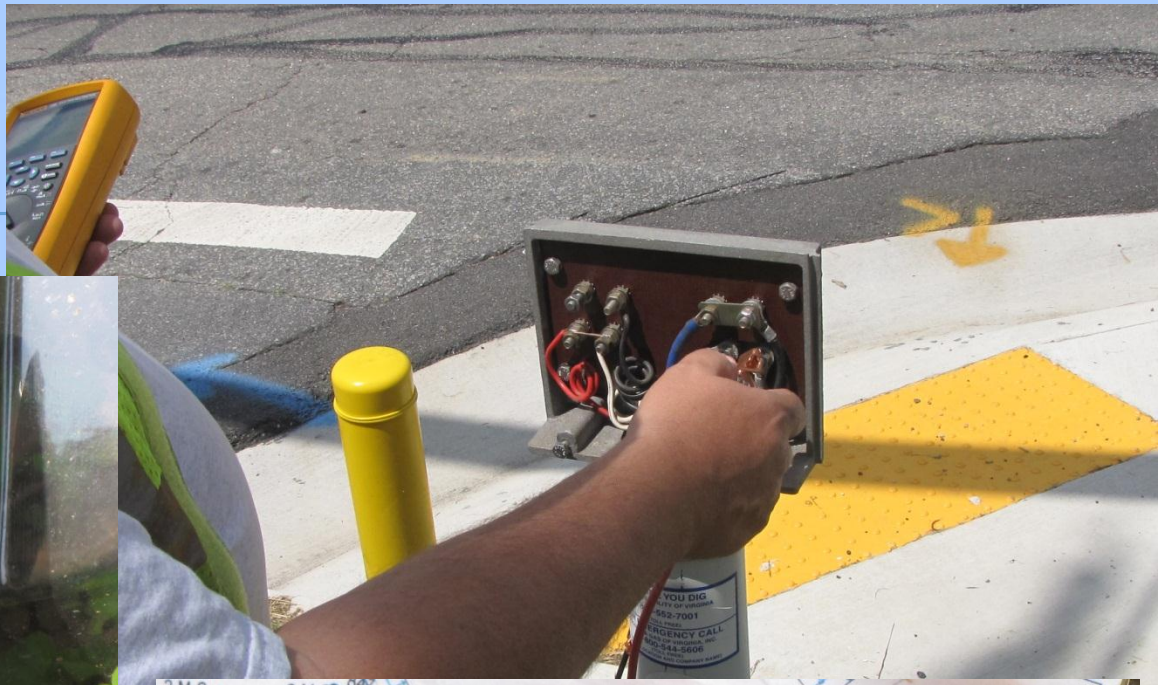


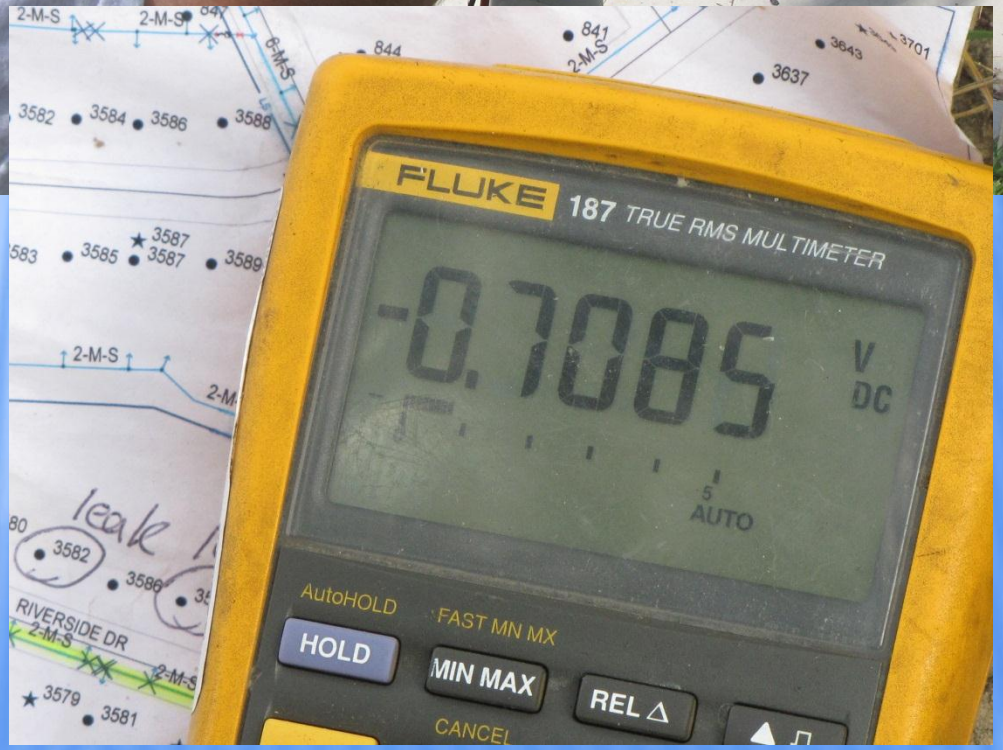
Main installed in 1994 with 2 test stations, test stations not monitored

Isolated risers - Not monitored for CP



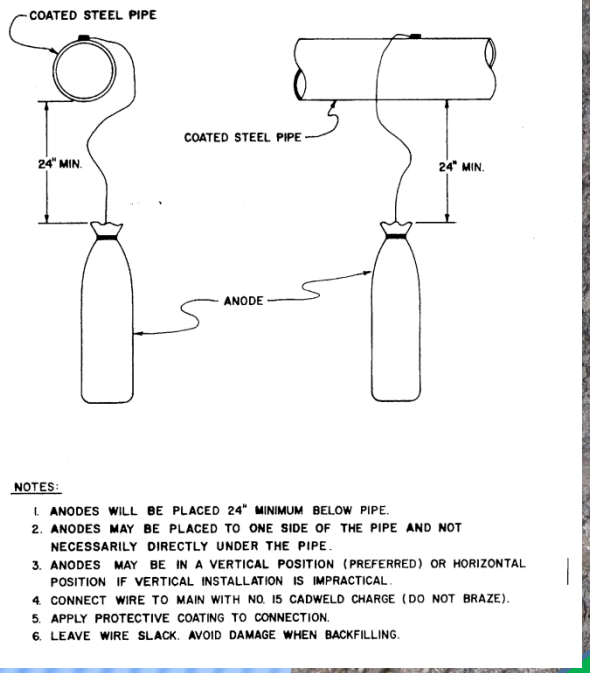
Mains installed in 1989, not placed under cathodic protection until 1997





Low readings on system

Not taking readings when doing repairs - Areas of active corrosion no actions taken

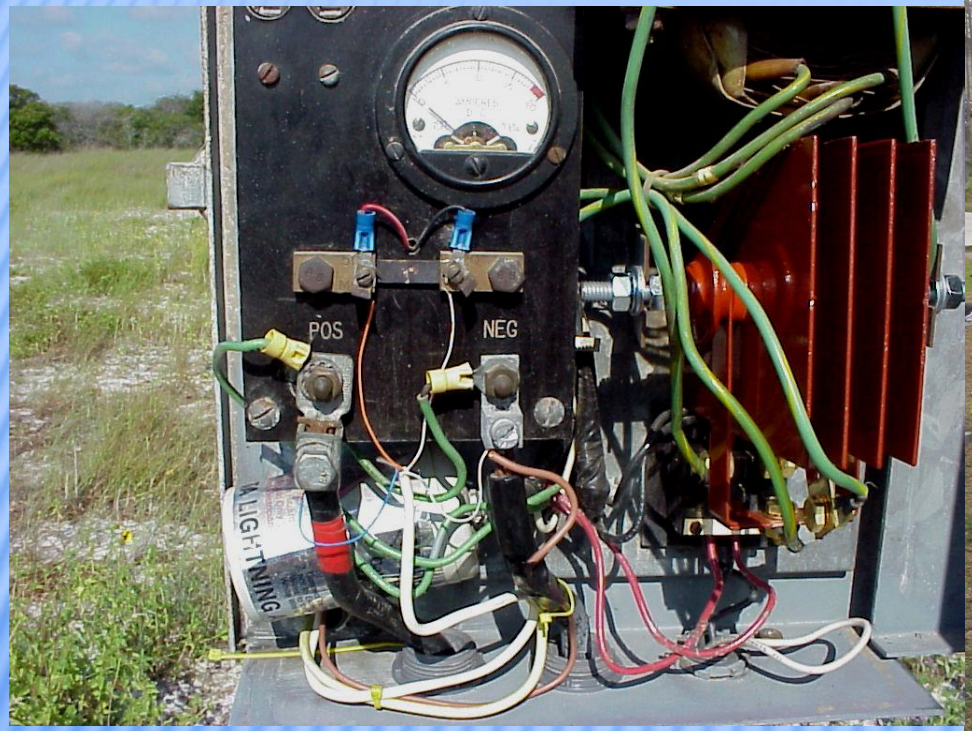


NOTES:

1. ANODES WILL BE PLACED 24" MINIMUM BELOW PIPE.
2. ANODES MAY BE PLACED TO ONE SIDE OF THE PIPE AND NOT NECESSARILY DIRECTLY UNDER THE PIPE.
3. ANODES MAY BE IN A VERTICAL POSITION (PREFERRED) OR HORIZONTAL POSITION IF VERTICAL INSTALLATION IS IMPRACTICAL.
4. CONNECT WIRE TO MAIN WITH NO. 15 CADWELD CHARGE (DO NOT BRAZE).
5. APPLY PROTECTIVE COATING TO CONNECTION.
6. LEAVE WIRE SLACK. AVOID DAMAGE WHEN BACKFILLING.

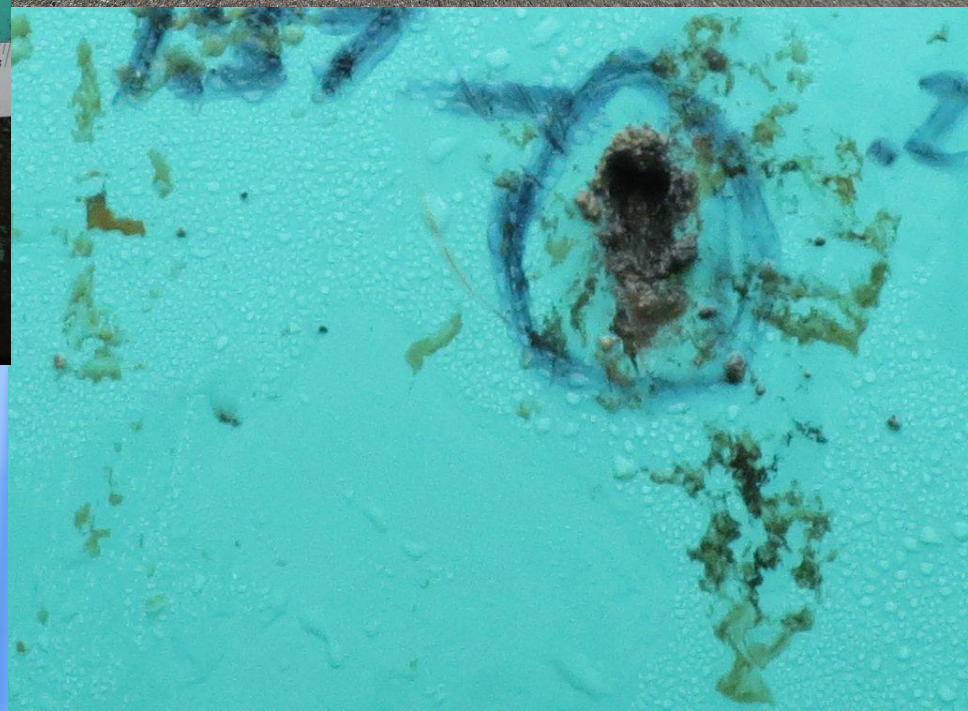
Anodes not installed properly

§192.465 (b)



Failure to inspect each cathodic protection rectifier impressed current power source six times each calendar year, but with intervals not exceeding 2 1/2 months, to insure that it is operating properly.

Phil Sadler
AC Corrosion



AC CURRENT ON STEEL PIPELINES

PERSONNEL HAZARD & INTERFERENCE CORROSION

- Probably not an issue with galvanic anodes
  - Grounding provided
- Interference with impressed current cathodic protection
  - Need to ground for AC without disrupting CP

NACE INTERNATIONAL PUBLICATION 35110

PREDICTING AC CORROSION

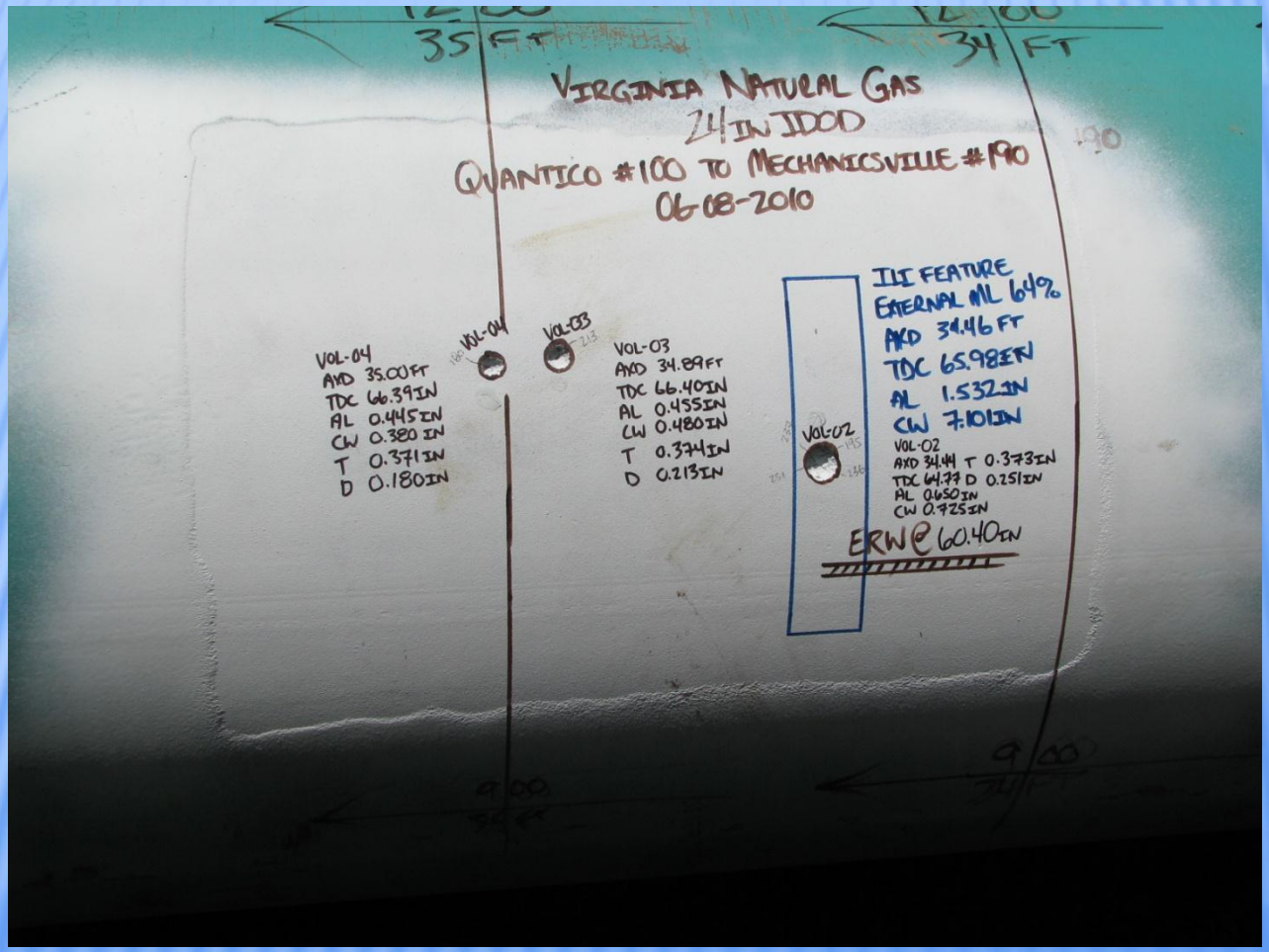
- Current density lower than 30 A/m2 (2.8 A/ft2): no or low likelihood;
- Current density between 30 and 100 A/m2 (2.8 and 9.3 A/ft2): medium likelihood; and
- Current density higher than 100 A/m2 (9.3 A/ft2): very high likelihood.

CURRENT DENSITY

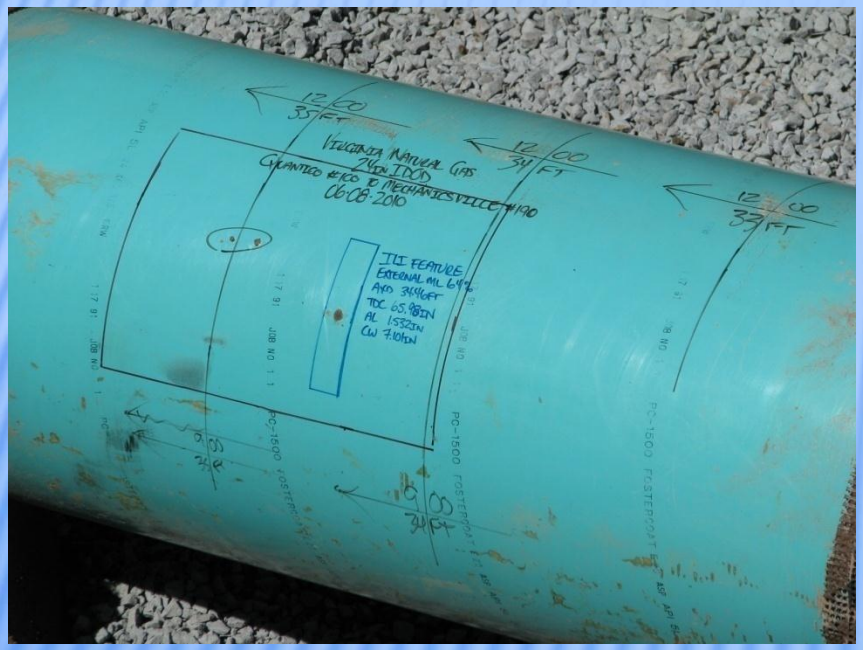
$$Iac = \frac{8 \times Vac}{\rho \times \pi \times d}$$

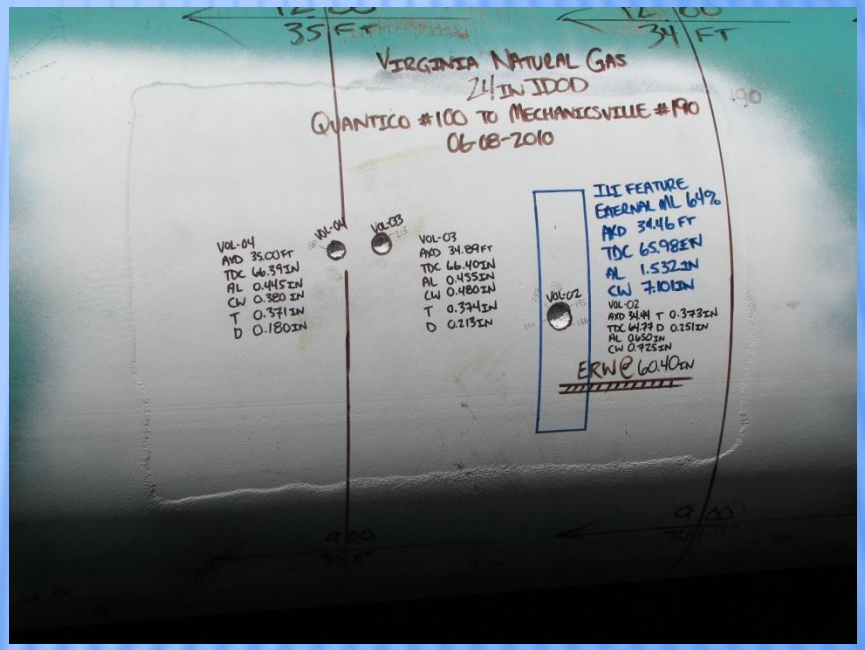
$$Iac = AC\ current\ density\ in\ A/m^2$$
$$\rho = soil\ resistivity, in\ ohm - meters$$
$$d = holiday\ diameter, in\ meters$$

AC CORROSION

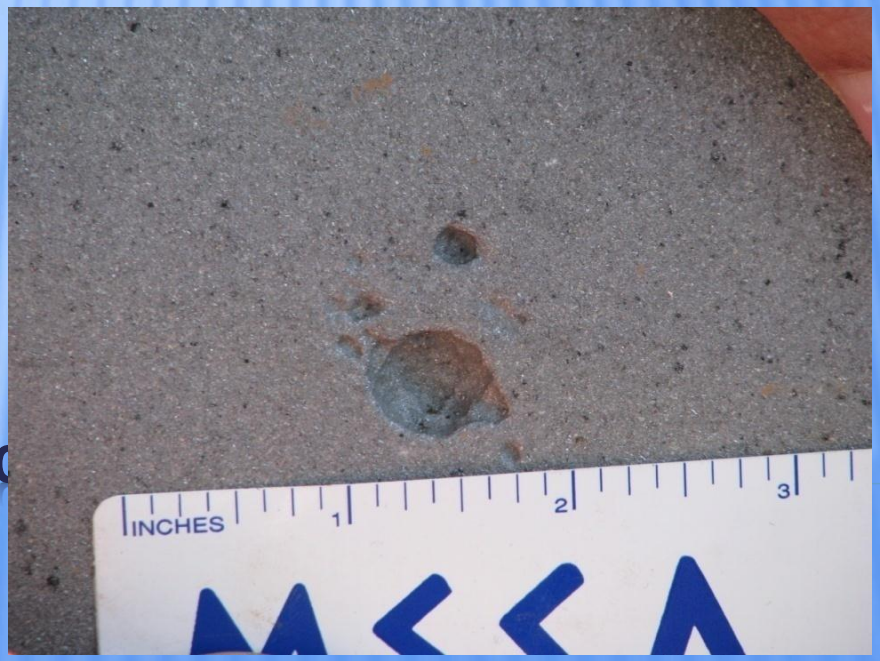


AC CORROSION





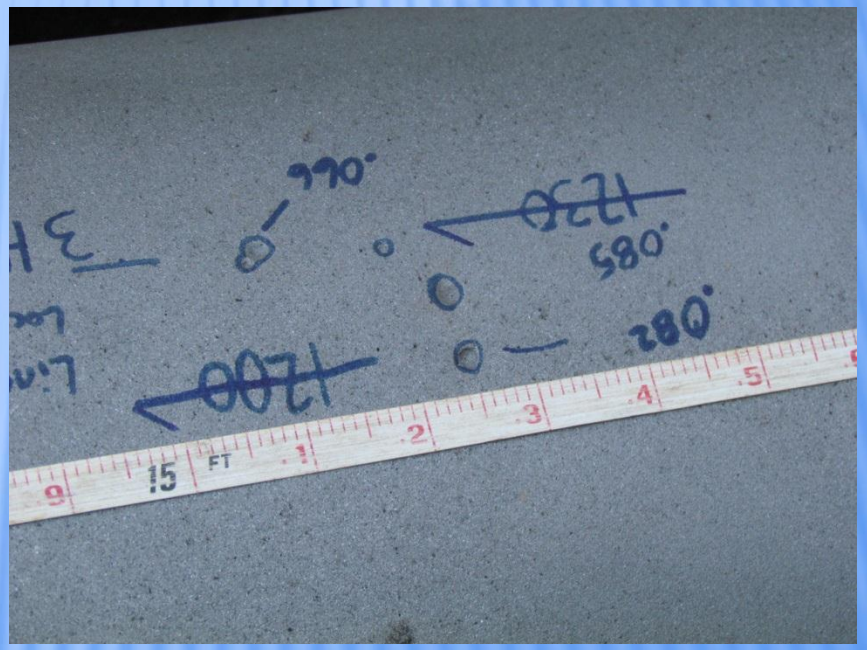
- Corrosion Product
- MFL Tool Results
  - Depth Under Call?



LOW AC VOLTAGE BUT LOW RESISTIVITY

- NACE states that the personnel hazard threshold is 15 Volts
  - It appears this is not unusual
  - Construction made difficult – grounding required
- Perhaps the threshold for corrosion is lower than 15 Volts
  - Low soil resistivity can influence current density

INTERFERENCE CORROSION HAS A SIMILAR APPEARANCE TO AC CORROSION



AC MITIGATION

- Three Operators have Installed AC Mitigation or Plan to Do So.
- Is It Working?
- How Should It Be Monitored?